VELA NETWORK EVALUATION AND AUTOMATIC PROCESSING RESEARCH

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This second quarterly report summarizes progress under the VELA Network and Automatic Processing Research program, Contract No. F08606-74-C-0033, during the period 1 February 1974 to 30 April 1974. Work in the following areas is summarized:

- VLPE Station evaluation
- Network analysis

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20.
- Signal detection
- Signal estimation
- First zone discrimination
- Seismic surveillance system

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SECTION I

INTRODUCTION AND SUMMARY

This second quarterly report summarizes progress made during the quarter from 1 February 1974 to 30 April 1974 on the VELA Network Evaluation and Automatic Processing Research program being carried out by Texas Instruments Incorporated at the Seismic Data Analysis Center in Alexandria, Virginia. Beginning in February, an additional task was begun involving the simulation of a seismic surveillance system. The six tasks of the program are:

- Evaluation of the Very Long Period Experiment (VLPE) stations
- Investigation of the detection and discrimination characteristics of a seismic network using VLPE, NORSAR, and ALPA data
- Investigation of signal detection techniques
- Investigation of signal estimation techniques
- Investigation of discrimination techniques using first-zone data
- Simulation of a seismic surveillance system consisting of a network of seismic stations

The software required for the first two tasks was developed under Contract F33657-67-C-1063. Most of the software for the remaining tasks are being generated under this contract.

Preliminary analysis of a January, February, and March 1973 event ensemble has been completed using VLPE, ALPA, and long-period NORSAR data. Analysis of a group of April 1973 events is underway. After these events are completed, a careful reassessment of all of the data will begin with the aim of refining and interpreting the results.

A program to compare the conventional power and Fisher detectors using Korean short-period array data is in final check-out. Two detector threshold algorithms have been selected for testing.

The majority of the new ABF program has been coded and checked out. Initial tests of the full program are expected in about one month. Two methods of implementing a distributed signal model algorithm have been formulated. Further analysis will be required, however, to determine which one can be most easily implemented.

The software for comparing conventional and envelope beamformers has been completed and a small group of signals and noise samples has been processed. A program to compare the relative detectability of signals on conventional and envelope beams is being developed.

Initial processing of a group of first-zone events using NORSAR short-period data and a moving window spectral analysis technique has been started.

The system simulation task began this quarter with two areas of effort. The first involved building a computer model of a seismic surveillance system to test and assess various operating characteristics. The second area is the development of an interactive control and display system for testing proposed interactive analysis procedures.

SECTION II

VLPE STATION EVALUATION AND NETWORK ANALYSIS

A. CURRENT STATUS

Evaluation of the detection and discrimination capabilities of the individual VLPE stations, ALPA, and the long-period NORSAR arrays has continued this quarter. Routine processing and analysis of the January, February, and March, 1973 Eurasian event ensemble (215 events) was completed and approximately 10 percent of the April 1973 event ensemble was completed. Parameters obtained from analysis include noise statistics, interfering event statistics, M_s-m_b values, LQ/LR ratios, and data quality. An evaluation of matched filters and the Three-Component Adaptive processor using VLPE data is still in progress.

VLPE data quality has improved. The 1972 VLPE data had on the average 3.8 stations with available and useable data, while during the January, February, and March 1973 period, there were about 6 stations with available and useable data. Horizontal data has improved but is still somewhat less reliable than the vertical data. It is being used whenever possible.

NORSAR long-period data from April 1973 apparently suffers from numerous sizable time gaps. Obtaining successful edits of this data has been difficult and more time-consuming than expected; however edits of most of the events in the April ensemble can probably be obtained.

Field data tapes spanning portions of time through 1 April 1974 have been received from stations ALQ, CHG, CTA, KIP, KON, MAT, TLO, and ZLP.

A report entitled "Observed Rayleigh Wave Group Velocities and Spectral Amplitudes for Some Eurasian Paths" was completed and submitted for approval.

B. FUTURE PLANS

Routine analysis of the remaining April 1973 events will be completed. Except for events of special interest, routine processing of events in groups will be concluded. The major thrust from that point will be toward refinement of the results. This will include calculating station corrections, revising measured M_s values, and redetermining the detection and discrimination capabilities of the individual VLPE stations, the VLPE station network, and the combined ALPA, NORSAR, and VLPE network.

SECTION III
SIGNAL DETECTION TECHNIQUES

A. CURRENT STATUS

Modification of the Fisher detector program continued during this past quarter. One version was completed which can accept either library or edited tapes as input. A second version was almost finished which uses data from the Korean short-period array.

Two detector mechanisms have been selected for comparative evaluation and have been coded into the programs. The first counts a detection only at the time when the test statistic passes, in an increasing sense, through the detection threshold level. The second method counts a detection whenever the test statistic exceeds the threshold level. Both methods incorporate a variable length of "dead" time during which the detector is inactivated.

B. FUTURE PLANS

Final checkout of the short-period Fisher detector will be completed shortly into this quarter. This version will be evaluated first using Korean data. The time periods for which Korean data are available will be assessed and, if possible, a period will be chosen so as to coincide with data analyzed by other members of the research group.

SECTION IV
SIGNAL ESTIMATION TECHNIQUES

A. CURRENT STATUS

Substantial progress was made in the coding and checkout of the new ABF program this last quarter. The initialization and execution phases have been checked out except for the filter application and update and the phase housekeeping routines. The evaluation and display phase is being coded.

Two approaches toward implementing a distributed signal model filtering algorithm have been formulated. The first approach would be to implement a constrained least-mean-squared error adaptive filter algorithm in the ABF program. It is not yet clear, however, whether or not this would be successful. The second approach would be to try classical multichannel filtering using MCF's derived from a distributed signal model.

The comparison of coherent and incoherent beamformers, using short-period data, progressed from software modification to the data analysis stage. The signal-to-noise ratios, defined as the ratio of a short-term average level (STA) to a long-term average level (LTA), have been measured for eight earthquake events and eight presumed underground explosions in the 1.5 - 2.5 Hz and 3.0 - 4.0 Hz passbands. The false alarm rate from noise has been measured for six noise samples in these same two passbands. The false alarm probability also was measured as a function of the length of the time-integration window by

using STA averaging times of 0.5, 1.0, 1.5, 2.0, and 2.5 seconds with a constant integration time of 30 seconds for the long-term average.

B. FUTURE PLANS

The ABF program will be completely checked out in the next quarter. This will include comparing results with those from the older fixed-point ABF program. Following checkout, analysis of the interfering event problem will be begun using selected data. A short-period version of the ABF program will be created to process Korean array data. Implementation of the distributed signal model will also be begun.

The incoherent beamformer will be evaluated using a small ensemble of signals and noise samples. A simulation study involving signals synthetically buried in noise will be initiated along with a small study of using Hilbert transforms for envelope formation.

SECTION V

FIRST ZONE DISCRIMINATION TECHNIQUES

A. CURRENT STATUS

During the last quarter short-period NORSAR data was received for approximately 40 event having epicenters at less than teleseismic distances from NORSAR. A preliminary analysis of these events is being obtained by applying a moving-window spectral analysis technique (Cohen, 1969) to the entire short-period signal episode in order to obtain the frequency-time-power structure of the signal. About 20 percent of these events have been examined to date.

B. FUTURE PLANS

The moving window analysis program will be modified to compute spectral ratios, complexities, and phase energy ratios such as S/P, Lg/P, Lg/S, etc. Similar analyses will be made on NORSAR long-period data.

SECTION VI

SYSTEM STUDY

A. CURRENT STATUS

The system study task is oriented toward the simulation of a seismic surveillance network. This simulation requires the development of a computer model of the system, and testing its operating characteristics under various conditions.

The planning phase for the simulator has been completed. A seismic data flow model will be developed for evaluating required storage capacity, the effect of timing errors, system reliability, and system reaction time. The system will be described by stochastic variables representing the operational phases such as communications, detection, and event processing carried out by a surveillance system. Statistics will be compiled by simulating the operation of the system under various design modes which should be realistic representations of an operating surveillance system.

The programming of the stochastic models for earthquake and station detection bulletin generation is nearly completed. One subroutine inputs seismic region and seismicity parameters, transmission parameters, and array station parameters. Another subroutine generates a stream of sequential events and false alarms and produces a set of sequential station bulletins for the various network stations.

The interactive software development phase is currently under way with the objective of implementing one or more interactive graphics processing techniques relevant to the surveillance problem on the PDP-15 computer located at the SDAC. Since April 1, Texas Instruments has had available 12 hours per week of block time on that computer. So far, this time has been used to develop an understanding of the operating environment of the PDP-15. Several basic general routines for display and data handling purposes have been developed. It is anticipated that these routines will be useful for software development purposes when the decision is made as to which specific interactive processing technique should be implemented.

B. FUTURE PLANS

A basic model of the system simulator will be developed and demonstrated by the end of the contract period. The interactive software development effort will continue in an experimental phase until a decision is reached as to which processing technique will be developed.

SECTION VII

REFERENCE

Cohen, T.J., 1969, Seismoprints, Seismic Data Laboratory Report No. 238, AFTAC Contract No. F33657-69-C-0913-PZ01, Teledyne Industries, Incorporated, Alexandria, Virginia.